

# MODIS Instrument Status

Science Team Meeting  
Greenbelt, MD

May 1, 1996

Thomas S. Pagano



SANTA BARBARA  
REMOTE  
SENSING



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4/96  
96-0174- 1



# Agenda

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- Instrument Development Status
- PFM Performance Update
- Test Program Overview
- Video

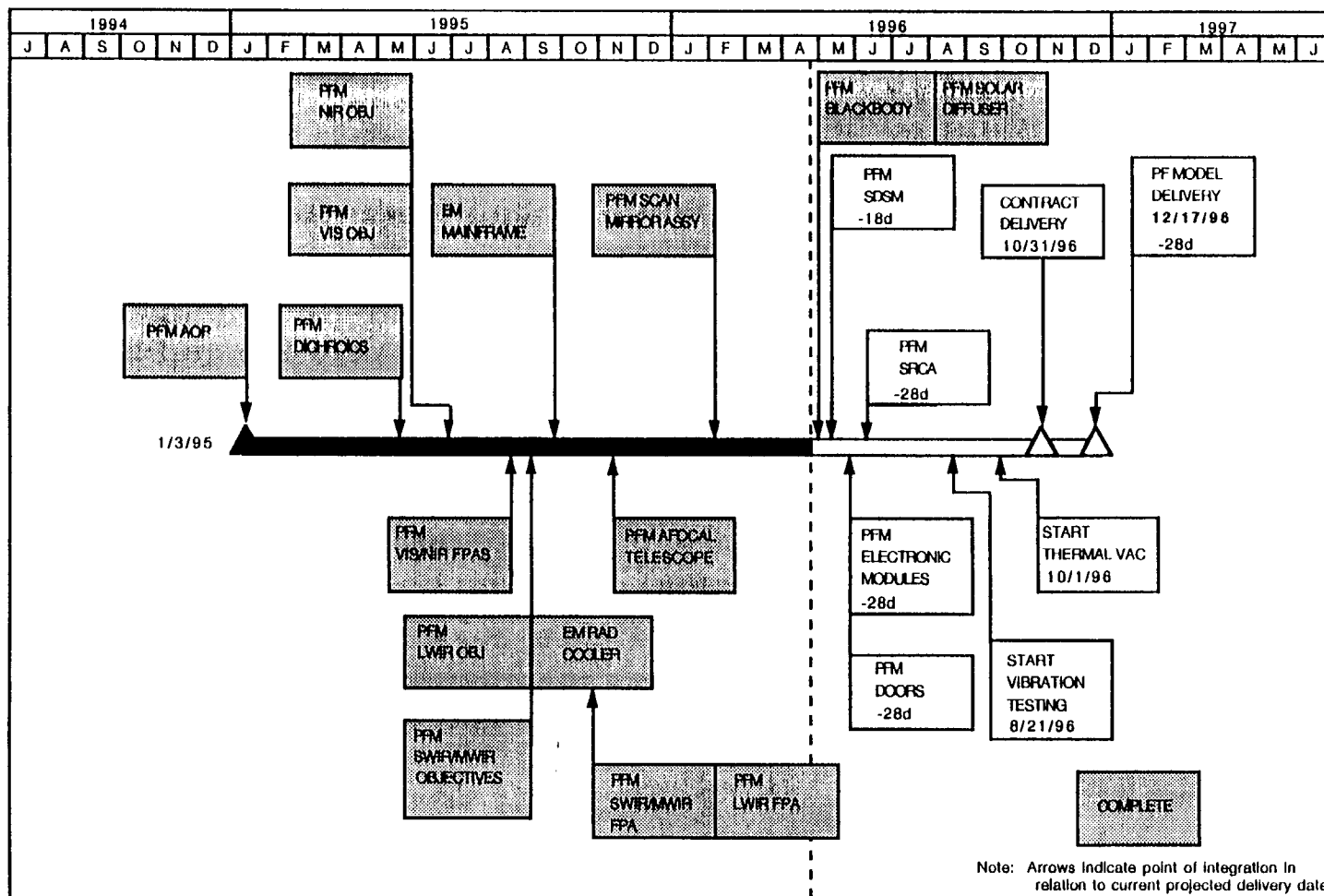


# Schedule Through Completion

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Status as of 4/22/96



## Major Events on PFM Since Last Meeting

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- Completed acceptance-level vibration tests of the AOA
- Reworked all AOA objectives to improve bonding; revibe complete
- Schaeffer Magnetics delivered SMA motor/encoder
- Scan Mirror balanced to GSFC/LMAS requirements
- Blackbody Assembly complete
- Solar Diffuser Assembly complete
- Integrated and aligned Scan Mirror Assembly
- Completed electronics module housings
- Installed Mainframe on MSF and MSF on RoTab
- Integrated and aligned ATA into mainframe
- Integrated and aligned OBA into mainframe
- Completed GSE test and data reduction software

### Remaining Tasks:

- Complete test, then integrate MEM, SAM, FAM
- Integrate Calibrators: SD, SDSM, SRCA, BB
- Integrate doors and install blankets
- Perform system tests



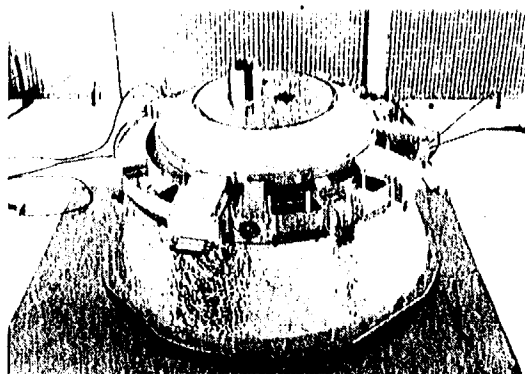
# MODIS PFM Primary Subsystems Complete

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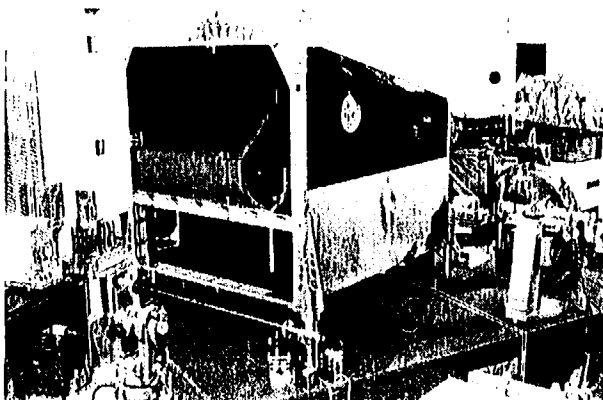
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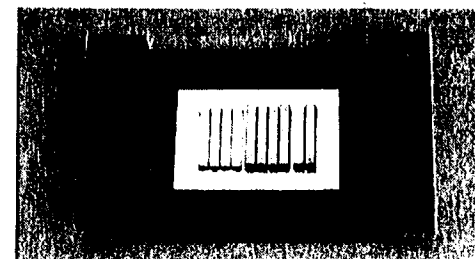
RADIATIVE COOLER



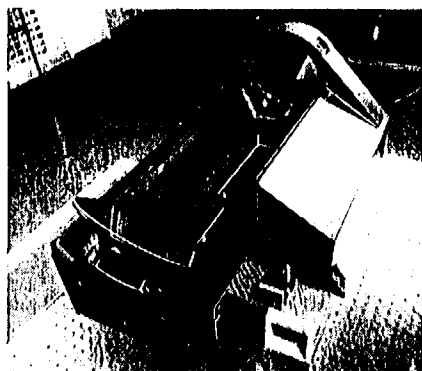
MAINFRAME



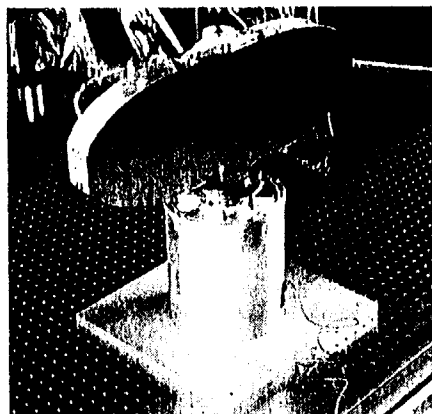
RE-IMAGING OPTICS



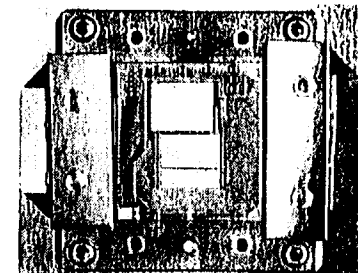
FILTER/DICHOICS



AFOCAL TELESCOPE



SCAN MIRROR ASSY.



FOCAL PLANES



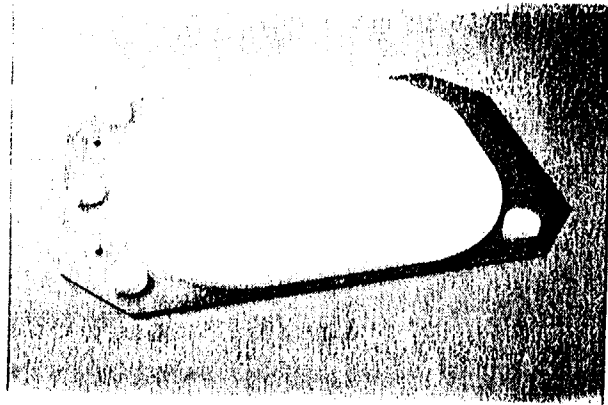
# MODIS PFM On-Board Calibrators Near Completion

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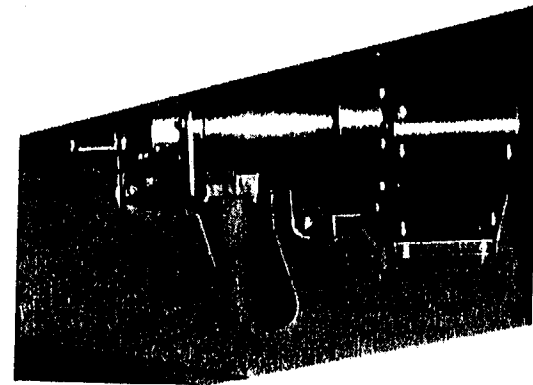
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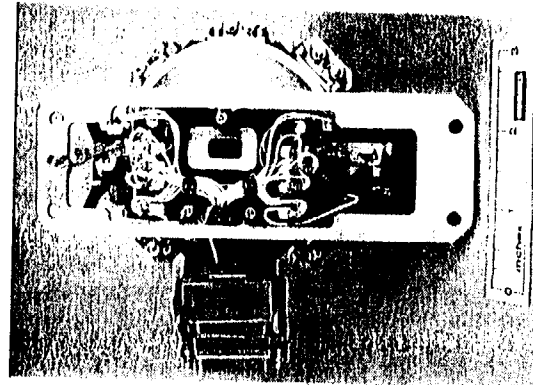
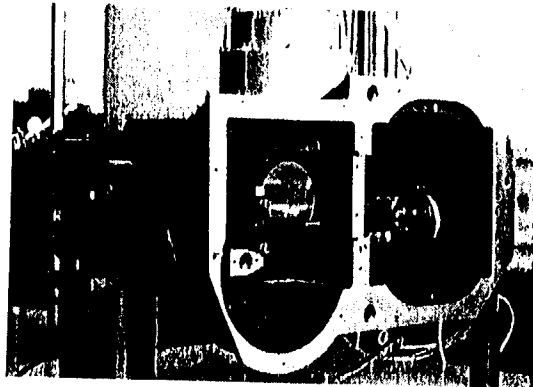
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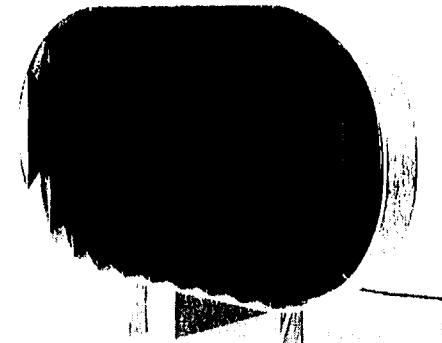
SOLAR DIFFUSER



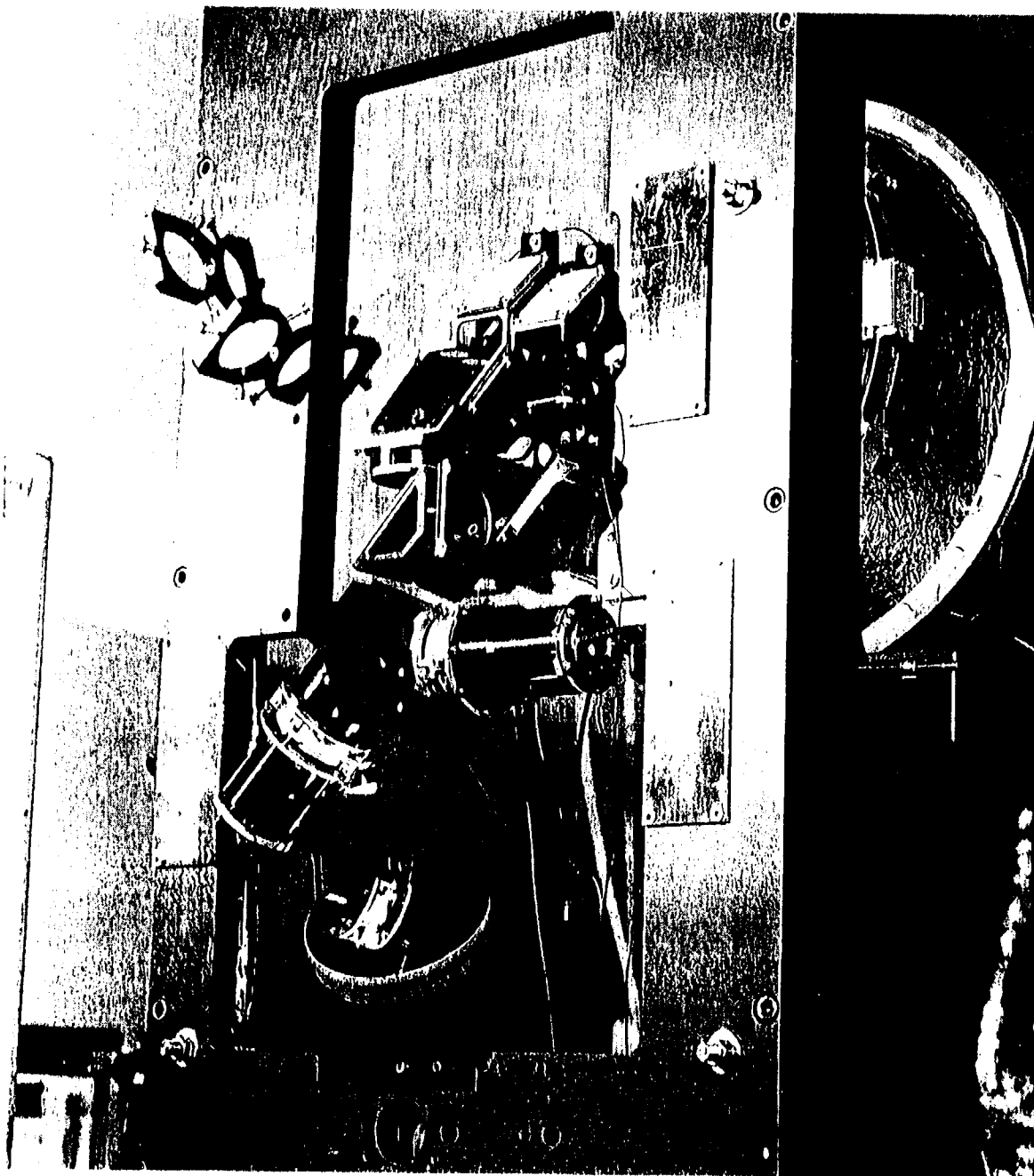
SDSM



SRCA



BLACKBODY



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## PFM AOA Test Configuration





# Remaining Subsystem Hardware in Test

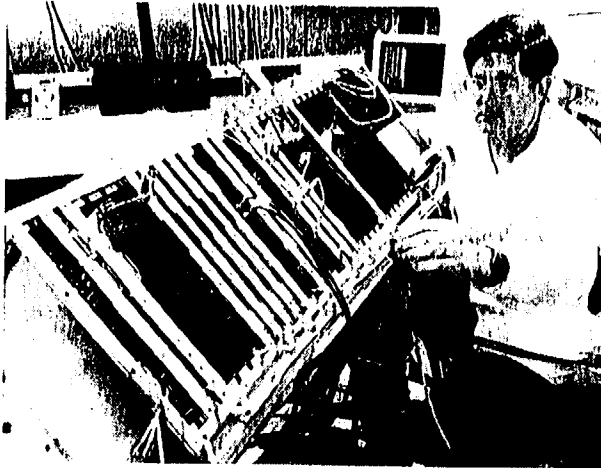
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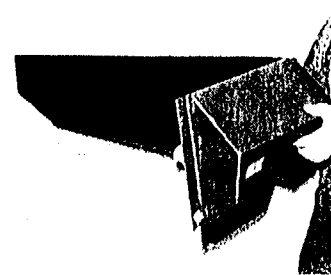
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MEM



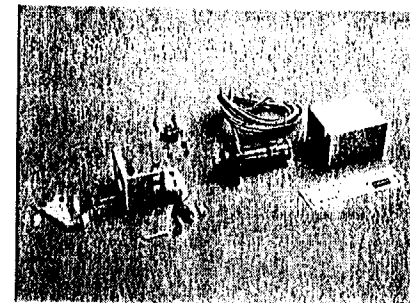
SUNSHADES



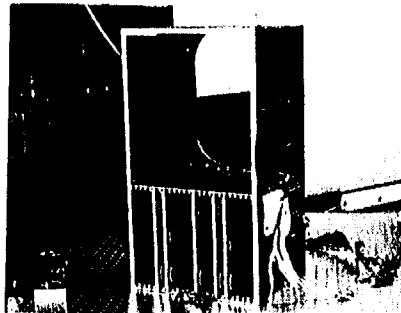
DOORS



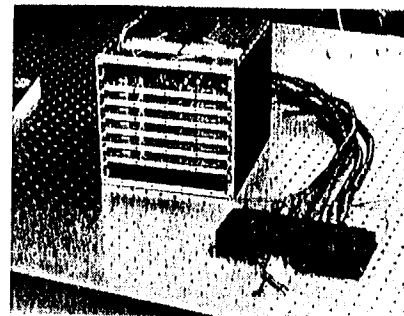
ACTUATORS



- BLANKETS
- CABLES
- SOFTWARE
  - FLIGHT
  - GSE



SAM



FAM





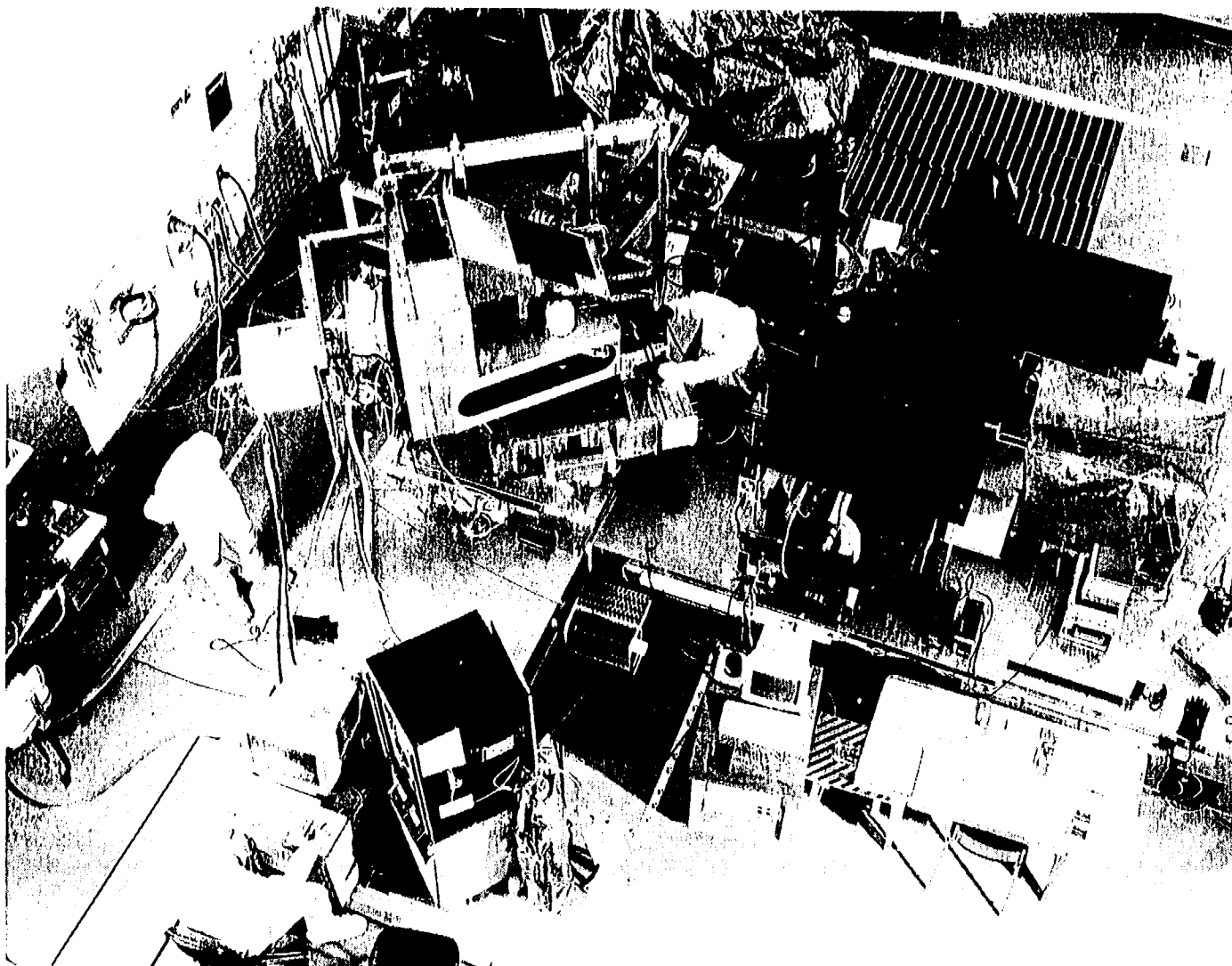
# MODIS Protoflight in Highbay

96-4-104

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# MODIS Protoflight Integration Set-Up



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# **PERFORMANCE PREDICTIONS FOR PFM**

## **Resource Usage**

**Radiometric Sensitivity (SNR, NEDT), Dynamic Range**

**Spatial: Registration, IFOV, MTF, NFR, Stray Light**

**Spectral: Center Wavelength, Bandwidth, Edge Range,  
Out-of-Band**

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# Resource Usage Meets Spec

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*Power allocations are SBRC goals. See Table 5.1-2 Note 1 for higher UIID allocations.*

Item	Weight (kg)	1-orbit Avg Pwr (W)	2-orbit Avg Pwr (W)	Peak Pwr (W)	Avg Data Rate (Mbps)	Peak Data Rate (Mbps)
Allocation	250	225	225	275	6.2	10.8
Current Estimate*	221.9	127.4	143.5	162.5	6.1	10.6
Previous Estimate	221.4	127.4	143.5	162.5	6.1	10.6
Change from Last Report	0.5	0	0	0	0	0
Margin to Allocation	28.1	97.6	81.5	112.5	0.1	0.2
Basis (%)						
Estimated	14.3	0	0	0	0	0
Calculated	8.2	0	0	0	100	100
Actual	77.4	100	100	100	0	0
1] 1-Orbit Avg is for full orbit of Science without Heated BB configuration. 2] 2-Orbit Avg is average of 1-Orbit Avg value & a full orbit of Science with heated BB calibration. 3] Data rate based on 40% day and 60% night per orbit duty cycle. 4] Power actuals reported for the Science & Heated BB configuration since availability of EM test data.						

\* Updated power values (slight increase) after completion of EM tests.

1/8/96



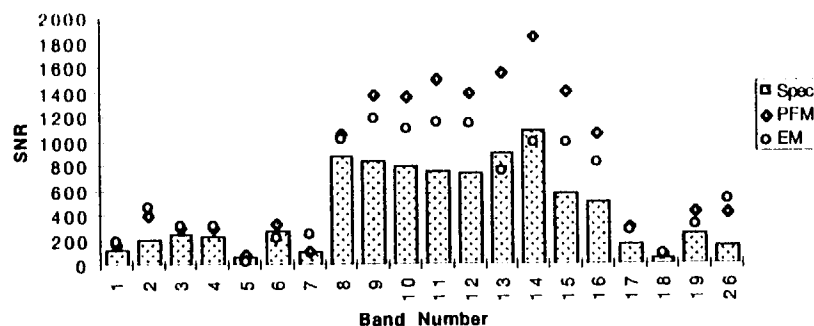
# PFM SNR/NE $\Delta$ T Calculations Reflect Good Electronics Performance

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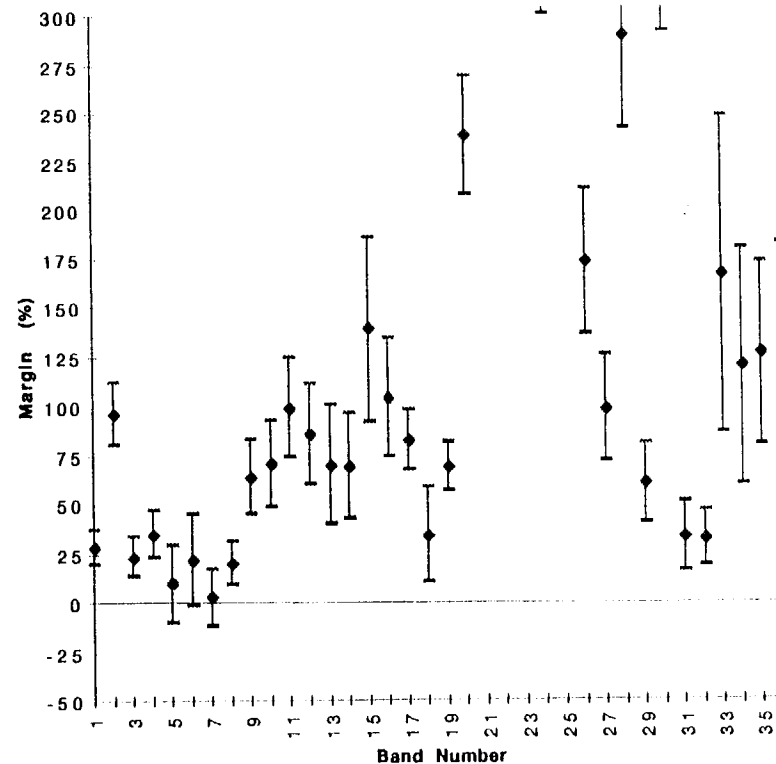
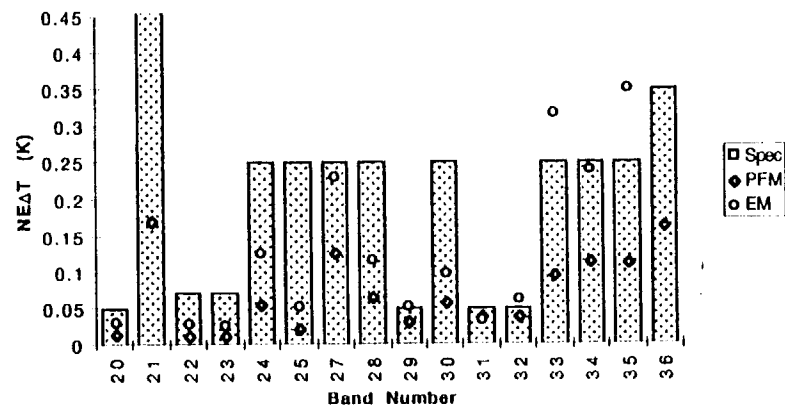


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SNR for MODIS Reflective Bands



NE $\Delta$ T for MODIS Emissive Bands





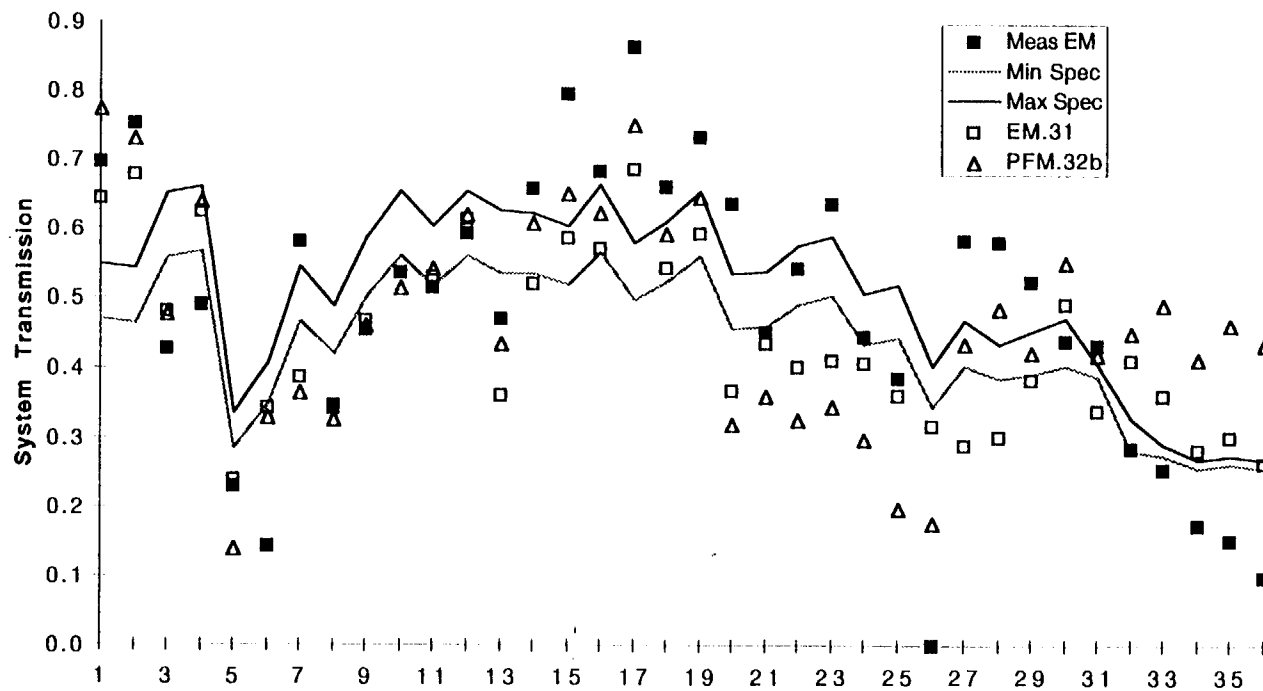
# Dynamic Range a Concern in NIR

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- NIR Throughputs higher than spec. will affect dynamic range

Measured and Required Optical System Transmissions



- Special test to be performed in May '96 to measure saturation levels



# Thermal Design Results in Reduced Temperatures

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- Reduced instrument temperature allows 15°C margin to saturation

## MODIS HOT CASE OPERATIONAL TEMPERATURES:

(Degree C)	Old Design	New Design	Temp.Red.
MODIS Inst.	24	20	4
MEM	34	23	11
FAM	32	21	11
SAM	32	14	18
Scan Mirror	27	23	4
Afocal Telescope	22	12	10
Aft Optics Assy.	22	7	15
Surv.Htr.Power	55 w	83 w	28 w



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ISOMETRIC VIEW  
FIG. 1  
1/4" = 1'-0"

ISOMETRIC VIEW  
FIG. 2  
1/4" = 1'-0"

ISOMETRIC VIEW  
FIG. 3  
1/4" = 1'-0"

ISOMETRIC VIEW  
FIG. 4  
1/4" = 1'-0"





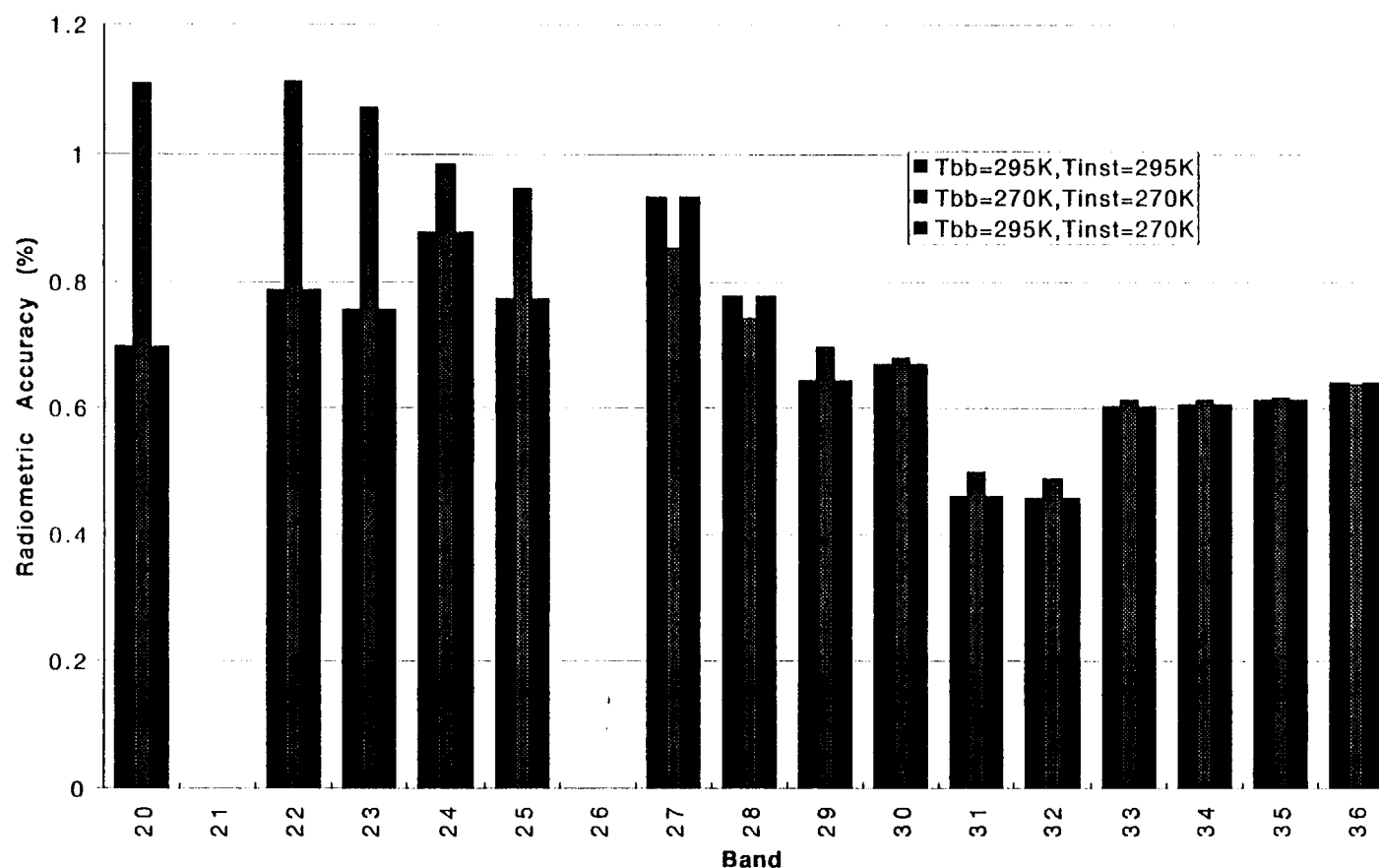
# When Instrument Cold, Best Accuracy for Warm On-Board Blackbody

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Radiometric Accuracy vs OBC Blackbody  
and Instrument Temperature: From MSAP 32c





# Spatial Performance: Alignment Progressing

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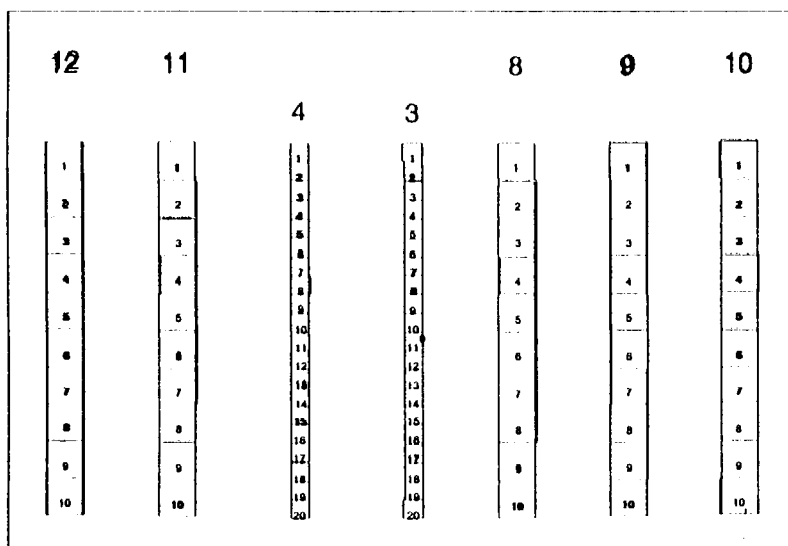
## VIS Correction

Scan -4.27  $\mu\text{m}$

Track +0.23  $\mu\text{m}$

Theta 0.002°

EFL 0.99924



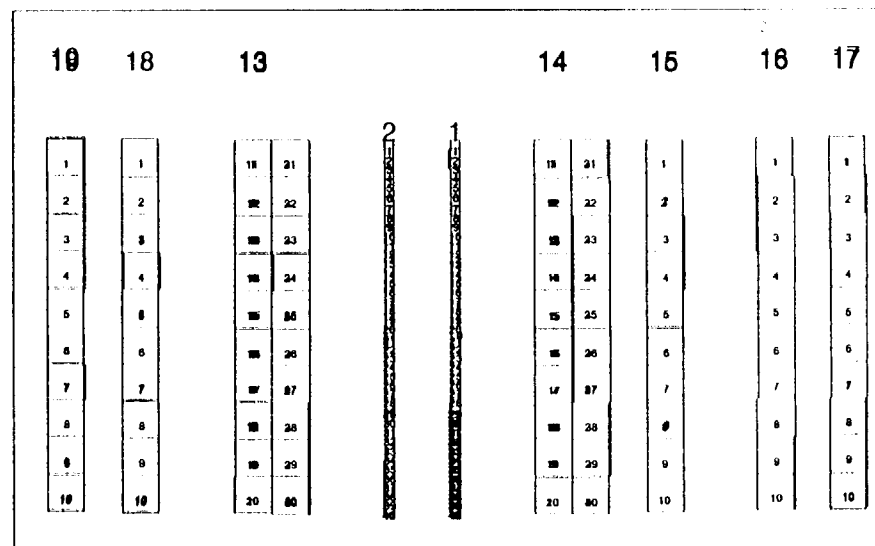
## NIR Correction

Scan -1.59  $\mu\text{m}$

Track +1.50  $\mu\text{m}$

Theta 0.0376°

EFL 0.99918



- Worst Case VNIR misregistration (5% 1KM Pixel)
- All MTFs in Spec

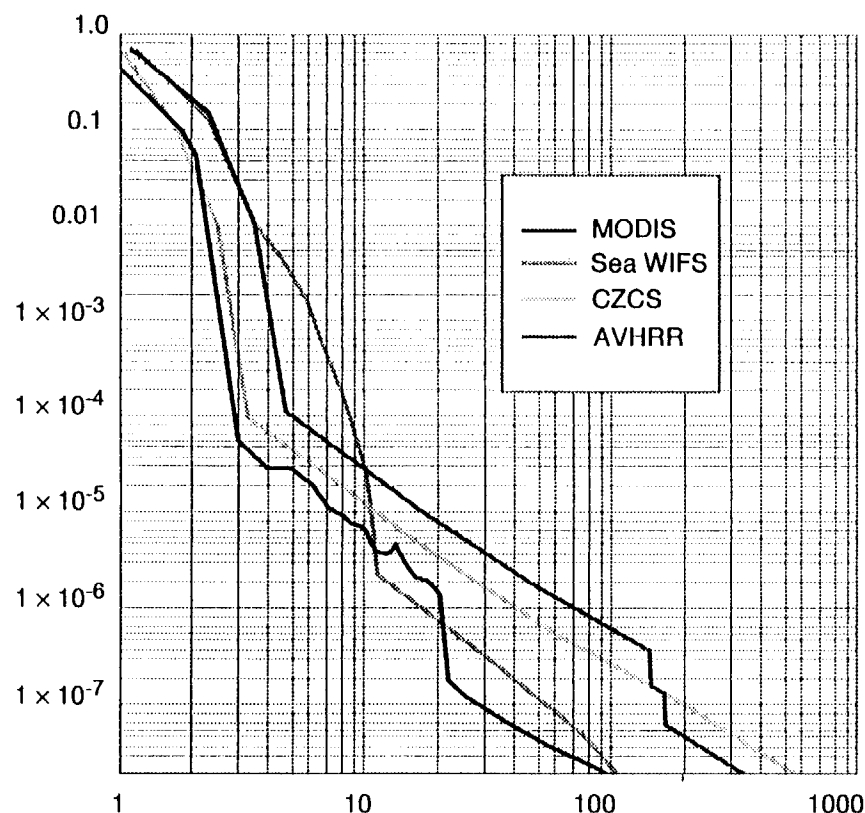


# MODIS Near Field Response Compared to Other Sensors

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- Response to 1 x 10 km cloud
- Less than  $10^{-4}$  response for MODIS at 3 km
- Contamination is a major player
  - MODIS must maintain approximately level 300
  - Sea WIFS as measured data
  - AVHRR & CZCS modeled at level 500
- Data generated by GSFC
- Subsystem data acquired at AOA level supports this model



# Scatter Model Shows Integrated Stray Light Within Specifications

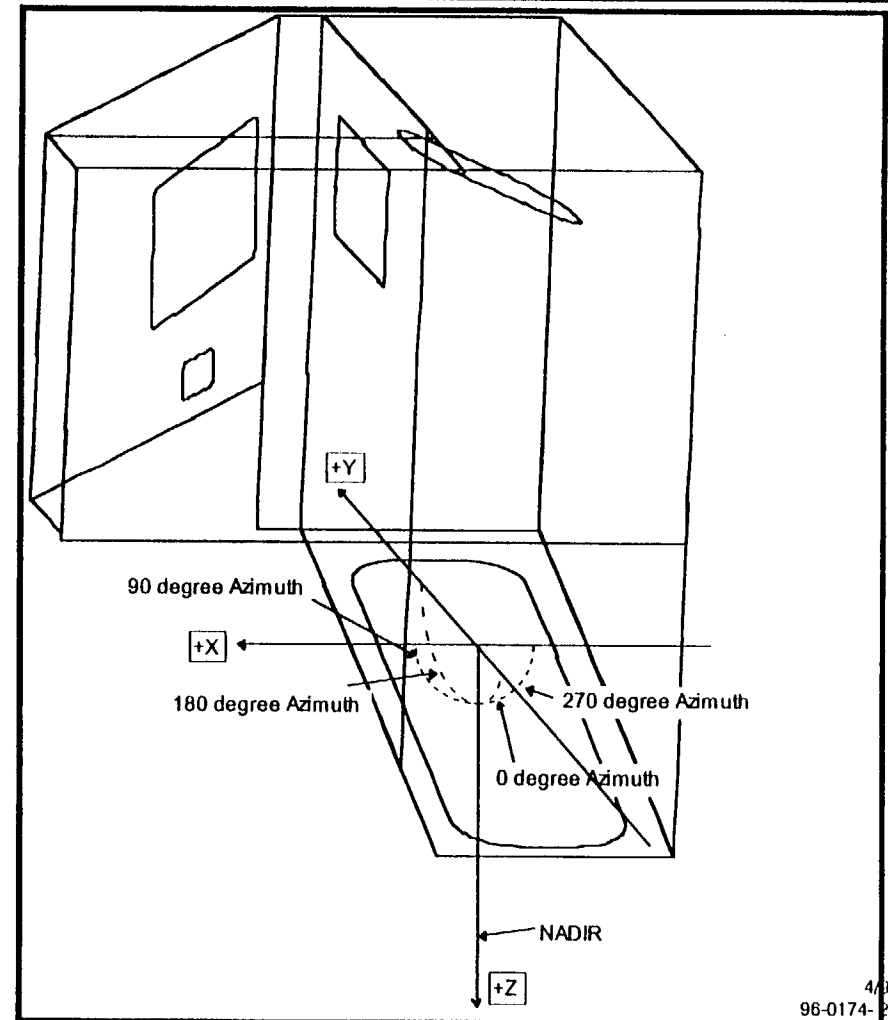
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- Rays were input into the system as collimated light using OARDAS
- Contamination level 400 used
- Input angles were swept from 2.4 degrees (out-of-field) to 63 degrees (Earth subtense) in the Azimuth planes
- Figure shows that
  - 0 deg Azimuth is the -YZ plane
  - 90 deg Azimuth is the +XZ plane
  - 180 deg Azimuth is the +YZ plane
  - 270 deg Azimuth is the -XZ plane
- Once input, rays scatter off surfaces to detector

## Results:

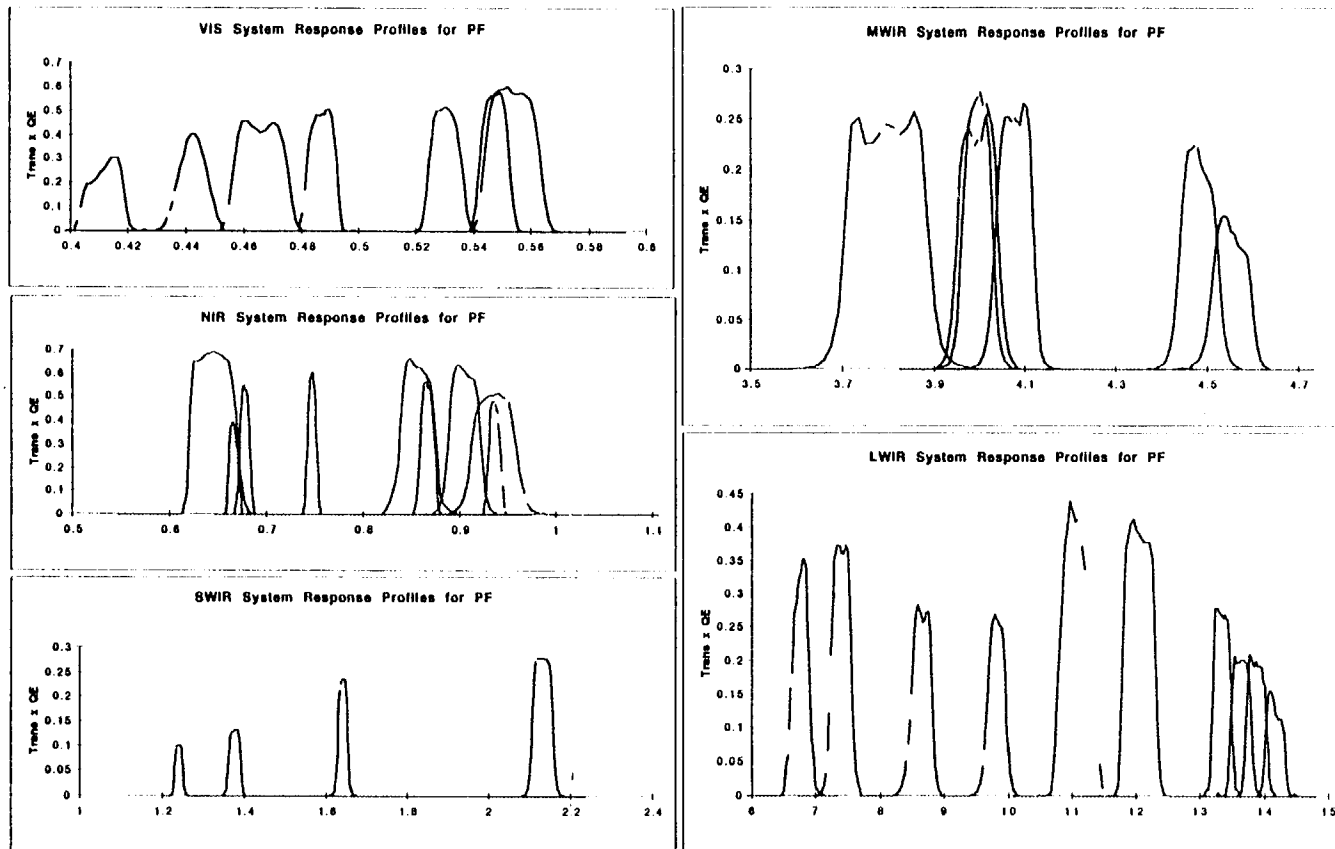
- Contamination dominates at level 400  
2x improvement at 300
- Total integrated stray light is 0.3% of image irradiance
- Stray Light specification limit is 0.4%





# 36 MODIS Spectral Bands Individually Tailored for Best Response

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- All profiles modeled for PFM based on component data

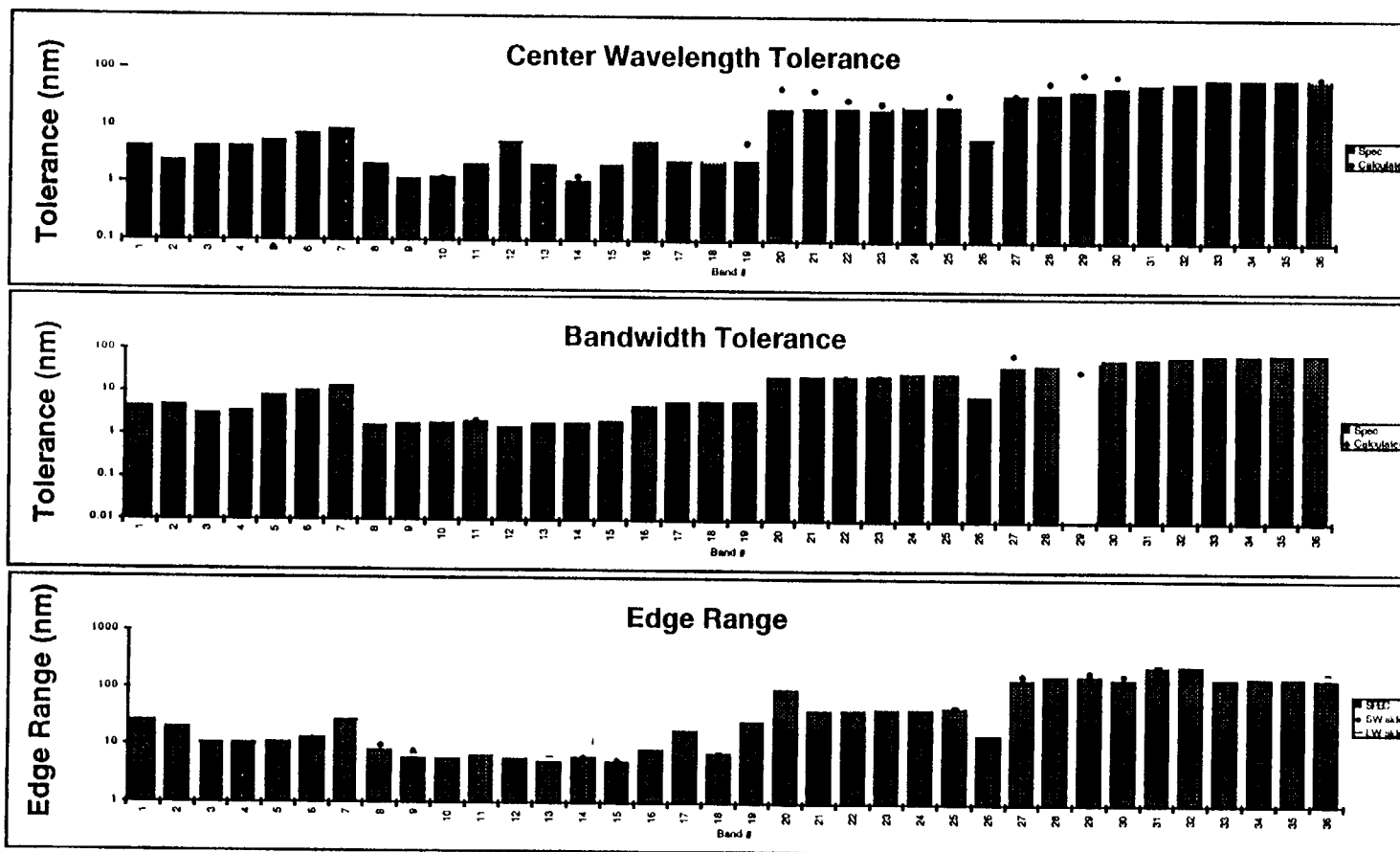


# PFM Spectral Noncompliances Identified – Waivers Submitted

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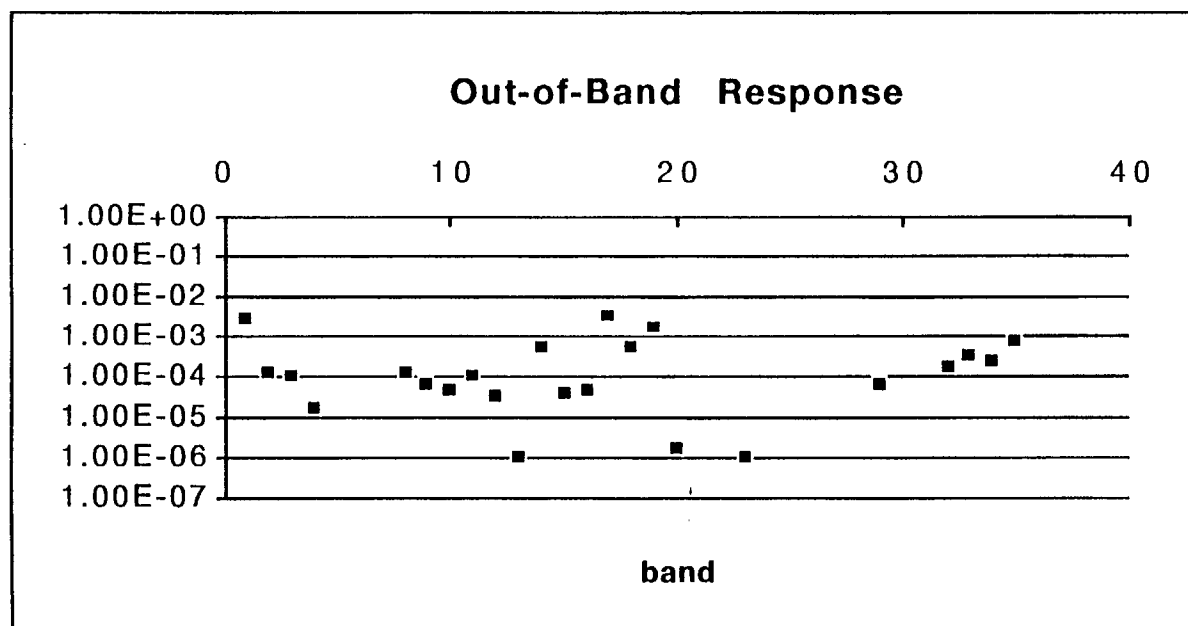
# Out-of-Band Rejection Expected to Be Very Good for MODIS PFM

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- Out-of-band response of the MODIS EM shown below; typically  $10^{-3}$  to  $10^{-5}$
- High rejection achieved by distributing blocking over many optical surfaces
- PFM results expected to be much better since test set-up improved
- Results represent average response over bandpass of filter used in test
- PFM tests will also include dispersive measurement,  $R(\lambda)$



Band	OOB r response
1	2.57E- 03
2	1.05E- 04
3	9.87E- 05
4	1.70E- 05
8	1.09E- 04
9	5.87E- 05
10	4.17E- 05
11	1.02E- 04
12	3.31E- 05
13	9.60E- 07
14	4.72E- 04
15	3.60E- 05
16	4.27E- 05
17	3.03E- 03
18	5.04E- 04
19	1.51E- 03
20	1.50E- 06
23	9.82E- 06
29	5.49E- 05
32	1.45E- 04
33	2.80E- 04
34	2.02E- 04
35	7.29E- 04

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# TEST PROGRAM OVERVIEW

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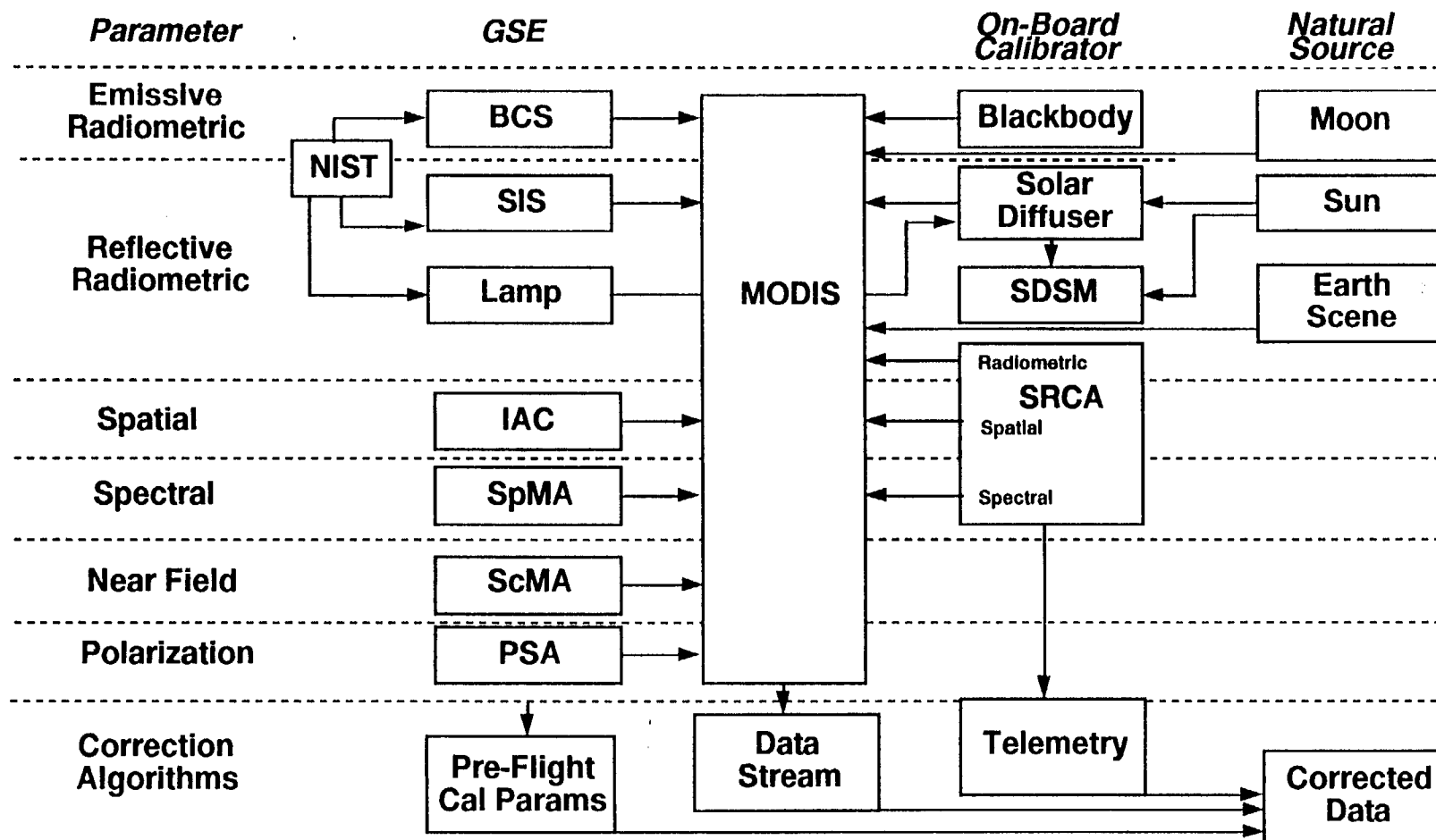


# Multiple Calibration Sources Used to Calibrate MODIS: Preflight and In-Orbit

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# MODIS Ground Support Equipment In-Place

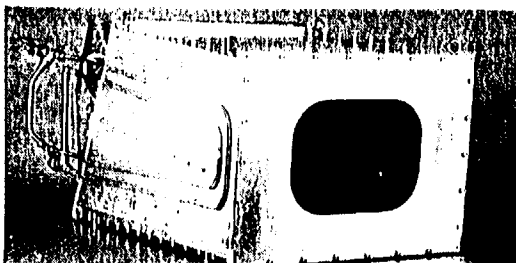
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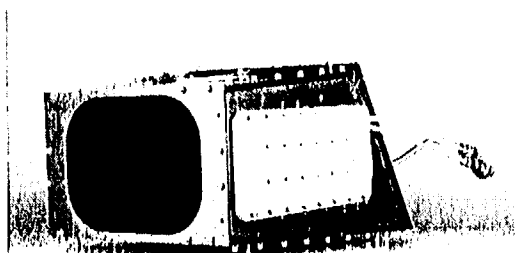
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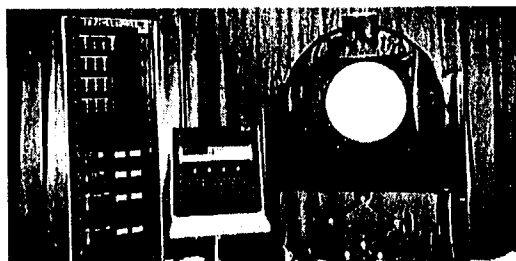
**BLACKBODY CAL SOURCE**



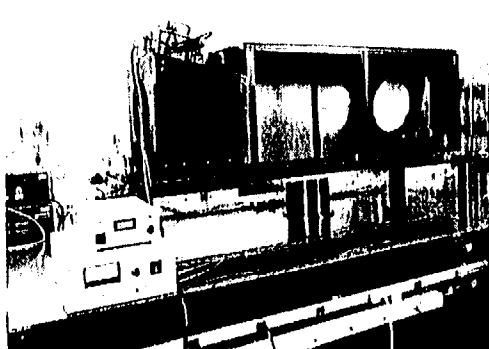
**SPACEVIEW SOURCE**



**SPHERICAL INTEGRATOR SOURCE**



**POLARIZED SOURCE ASSY**

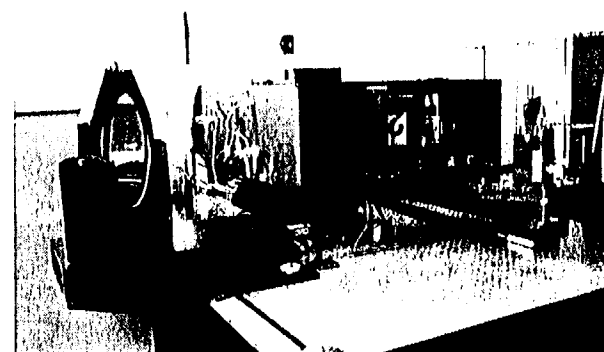


**INTEGRATION AND  
ALIGNMENT COLLIMATOR**

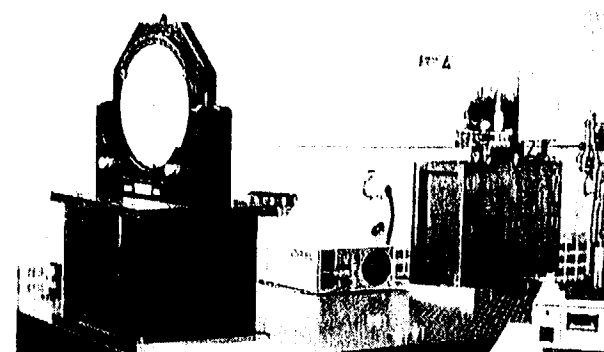


**BENCHTEST COOLER  
SYSTEM TEST COMPUTERS**

**SPECTRAL MEASUREMENT ASSY**



**SCATTER MEASUREMENT ASSY**





# Test Plan Covers Major Performance Areas

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- **Radiometric Performance**
  - Sensitivity: SNR,  $NE\Delta T$
  - Linearity
  - Accuracy
  - Stability
- **Spatial Performance**
  - IFOV, MTF
  - Registration
  - Pointing Accuracy
  - Field of View, Response vs Scan Angle
- **Polarization Insensitivity**
- **Spectral Response**
  - In-Band
  - Out-of-band Integrated
  - Out-of-band dispersive
- **Stray Light**
  - Near Field Response, PSF
  - Spurious Response
- **Reduced test program preserves essential characterization and calibration**
- **Electrical Tests**
  - Fixed Pattern Noise
  - Differential Nonlinearity of A/Ds
  - Electronic Calibration
- **On-Board Calibrators**
  - Solar test for SD and SDSM
  - Blackbody Calibration
  - SRCA Cross Calibration
- **Functional Tests**
  - Command and Telemetry
  - Data Stream Verification
  - Door Functional
  - Redundancy
  - Control Systems
- **Environmental**
  - Temperature cycling; thermal balance
  - Vibration
  - EMC, EMI



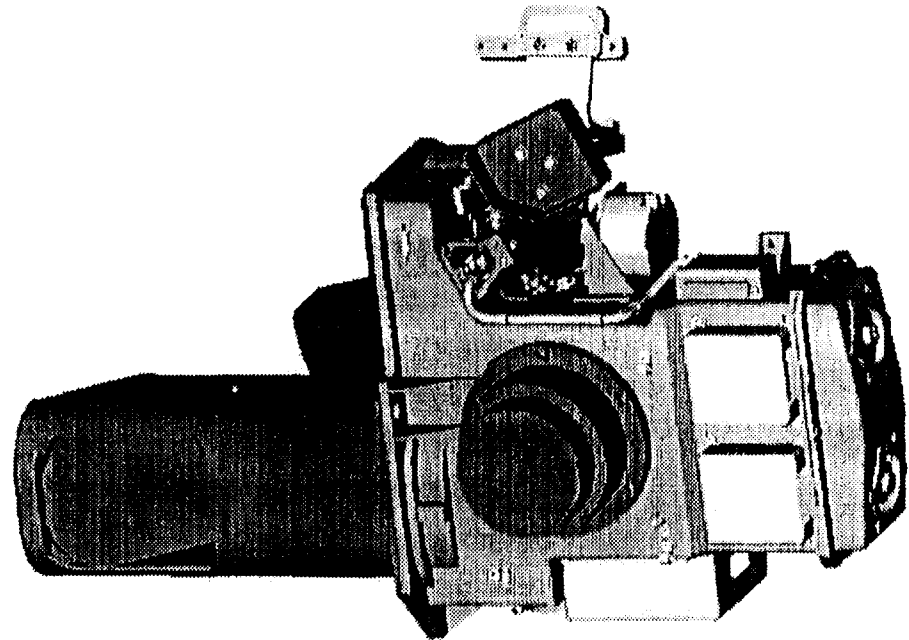
## SRCA Provides Testing at Many Levels

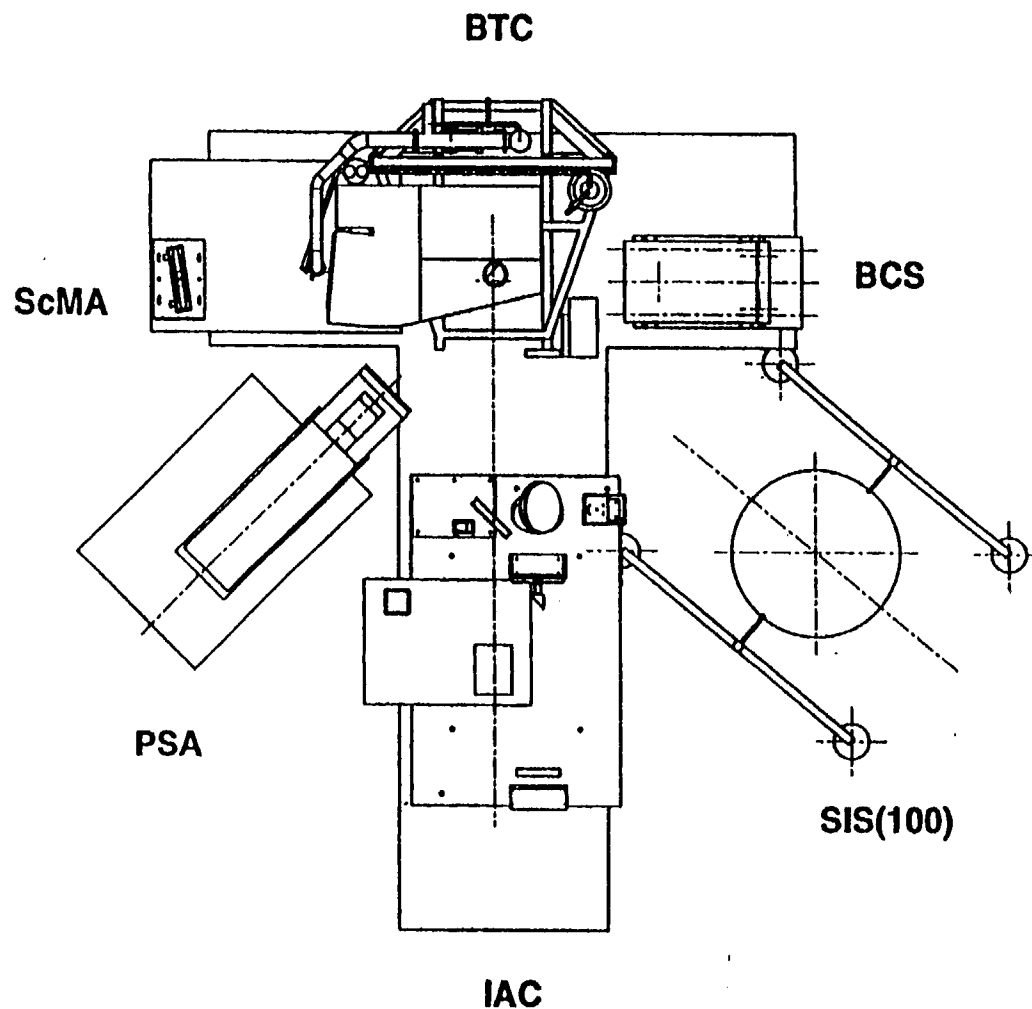
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- **Thermal Vacuum at SBRC**
  - Cross-calibration of radiometric, spatial and spectral performance
- **Post delivery testing at LMAS**
  - Only source for VNIR/SWIR testing at LMAS
  - Testing can be performed with or without all doors closed in any environment
- **In-orbit testing**
  - Spatial, Spectral, Radiometric stability monitoring
  - Possibly contamination/scatter monitoring





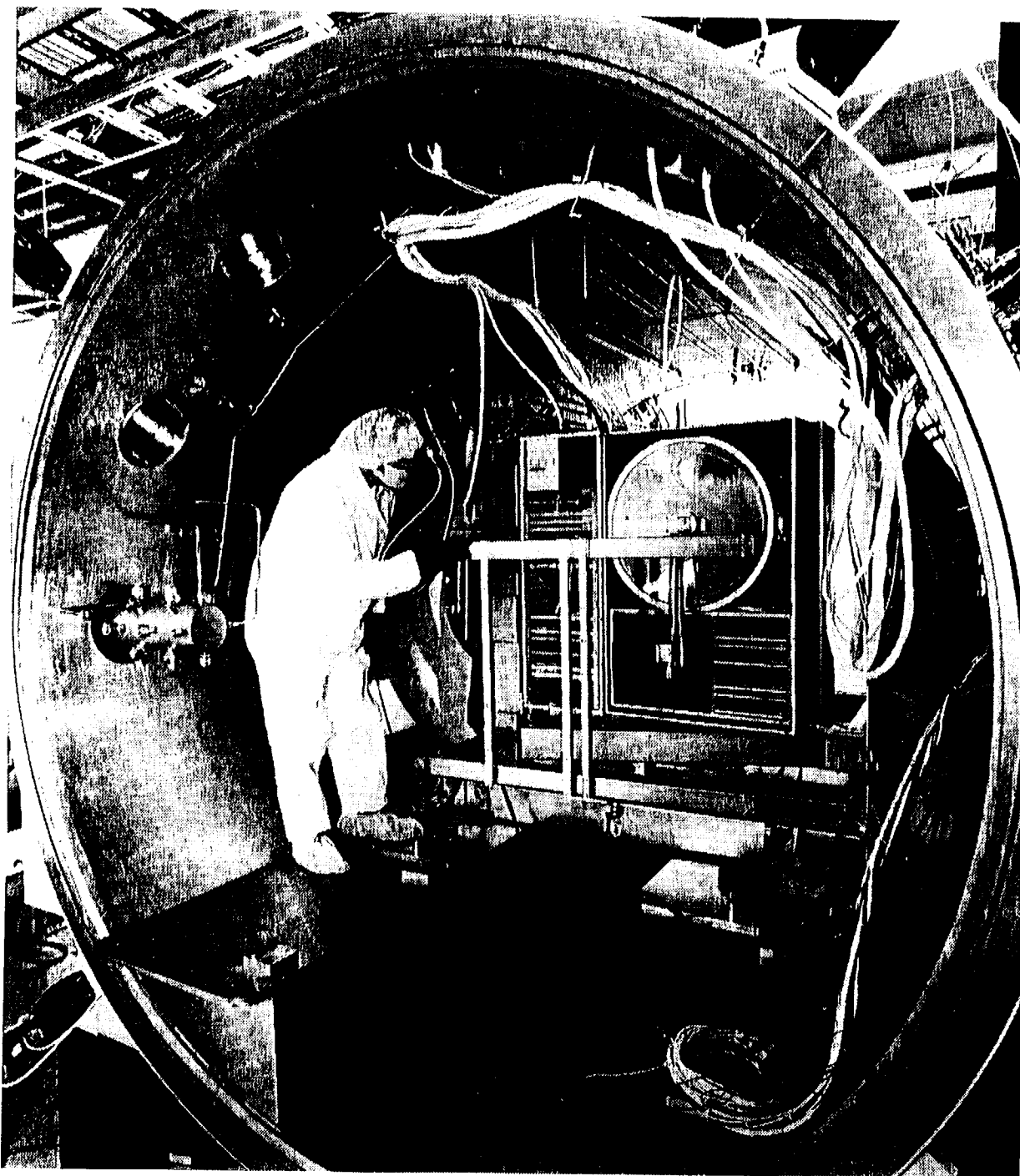
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# Proposed Test Area Set-up for Testing MODIS PFM Under Ambient Conditions





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95-3-79 (8)

# MODIS E.M. Installed in MODIS Calibration Chamber (Interior)





## Summary and Conclusions

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- All PFM hardware subsystems complete in June
- Optical Bench integrated into Mainframe
  - Aft Optics Assembly (includes all FPAs)
  - Afocal Telescope Assembly
  - Radiative Cooler Assembly
- Scan Mirror Assembly complete and integrated into Mainframe
- Performance models based on component data predict good instrument performance
- Reduced system test program preserves critical pre-flight calibration and characterization
- GSE ready for system test: sources, software, etc.  
Procedures in work